



GOING NUTS:

Developing peanut shell fuel briquettes
for household use in Malawi

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In this presentation...

1. Background
2. Goals
3. Briquette Design
4. Combustion
5. Emissions
6. Implementation
7. Recommendations



Background on Malawi

8 million people (>70% below poverty line)

Highly agrarian, peanut farming common

Biomass more than 90% of household fuel use

- Fuel wood
- Charcoal

Multiple stove types used

Problems identified

- Deforestation, management of dwindling resources
- Health problems from inhalation of smoke



Full Belly Project

Mission: “to design and distribute **income-generating** agricultural devices to improve life in developing countries.”

Developed universal nut sheller

- Can shells be used?





Overarching Goal

- Design and make a fuel briquette that is
 - easy-to-make,
 - affordable,
 - that uses local materials, and
 - burns well with
 - same or lower emissions than comparable biomass feedstocks



Semester Deliverables

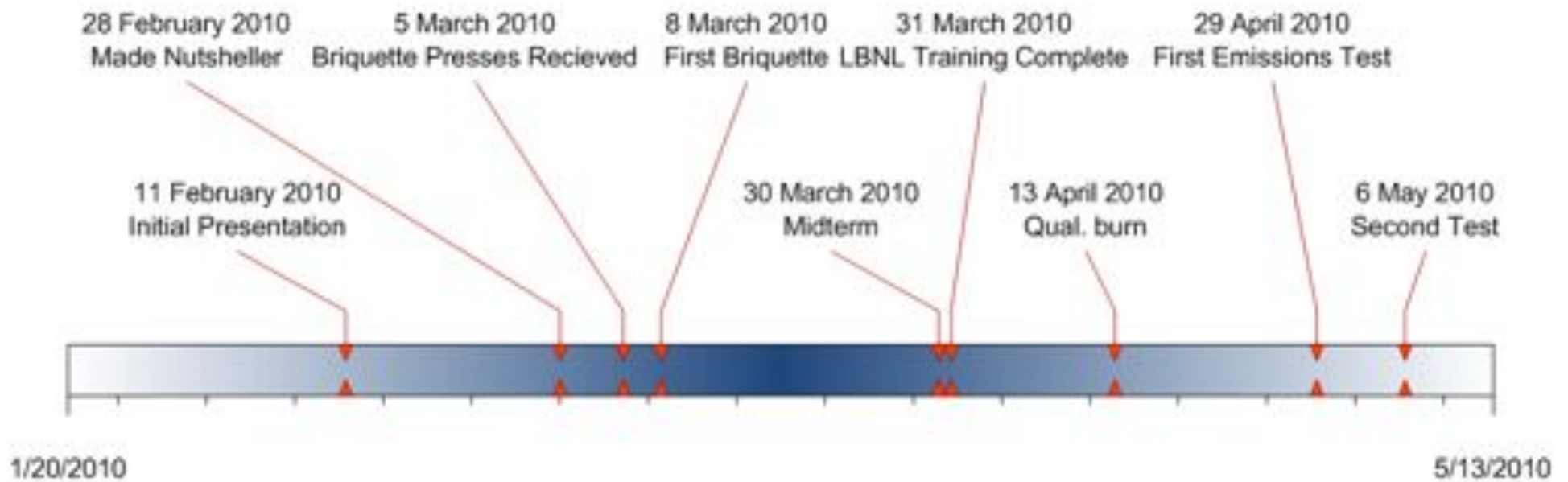
- Briquette design
 - Process
 - Briquette recipe
- Qualitative combustion test
- Quantitative emissions test
- Project viability documents
 - Implementation model
 - Rough market analysis
 - Stakeholder analysis



Timeline

		Name	Duration	Start	Finish
1		Assign team roles	0 days	1/29/10 8:00 AM	1/29/10 8:00 AM
5		Contact mentors	3 days	1/30/10 8:00 AM	2/3/10 5:00 PM
10		Get/make press	7 days	2/5/10 8:00 AM	2/15/10 5:00 PM
13		Establish storage space	0 days	2/5/10 8:00 AM	2/5/10 8:00 AM
15		Submit initial budget	0 days	2/11/10 8:00 AM	2/11/10 8:00 AM
6		Initial Class Report	0 days	2/11/10 11:00 AM	2/11/10 11:00 AM
2		LBPL Safety Training	1 day	2/12/10 8:00 AM	2/12/10 5:00 PM
3		Get peanuts/hulls	0 days	2/12/10 8:00 AM	2/12/10 8:00 AM
9		Get/make binding ag...	1 day	2/12/10 8:00 AM	2/12/10 5:00 PM
4		Get peanut hulling ma...	0 days	2/12/10 5:00 PM	2/12/10 5:00 PM
11		Make first briquettes	1 day	2/16/10 8:00 AM	2/16/10 5:00 PM
12		Emissions test briquet...	1 day	2/18/10 8:00 AM	2/18/10 5:00 PM
14		Test different binders...	42 days	2/19/10 8:00 AM	4/19/10 5:00 PM
7		Midterm Presentation	0 days	3/30/10 11:00 AM	3/30/10 11:00 AM
8		Midterm Report	0 days	4/2/10 4:00 PM	4/2/10 4:00 PM
16		Final presentation	0 days?	5/13/10 8:00 AM	5/13/10 8:00 AM
18		Delivery of team binder	0 days?	5/14/10 8:00 AM	5/14/10 8:00 AM
17		Final paper	0 days?	5/14/10 5:00 PM	5/14/10 5:00 PM
CE260 Project - Peanut Hull Briquettes - page 1					

Timeline



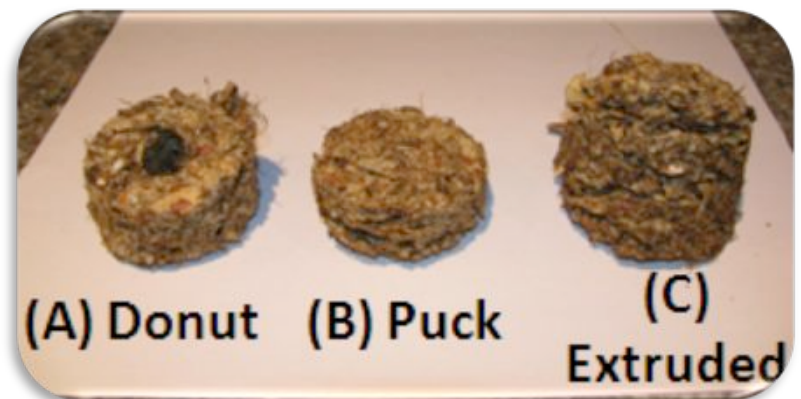
The Briquetting Process



Photo credit: Tammy Harrell



Briquette Design: Press & Shape



Briquette Shape

Doughnut

Pressed Puck

Extruded

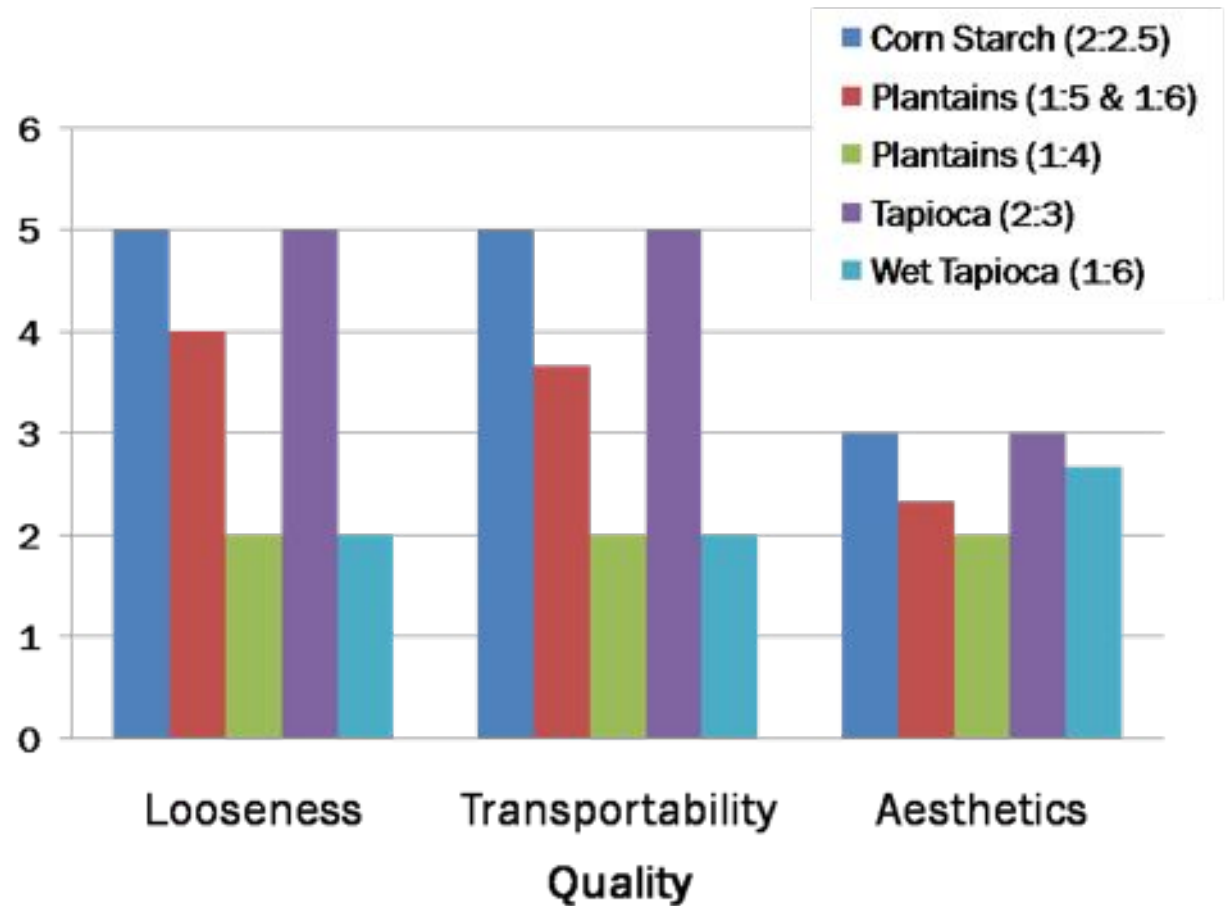


Briquette Design: Binder

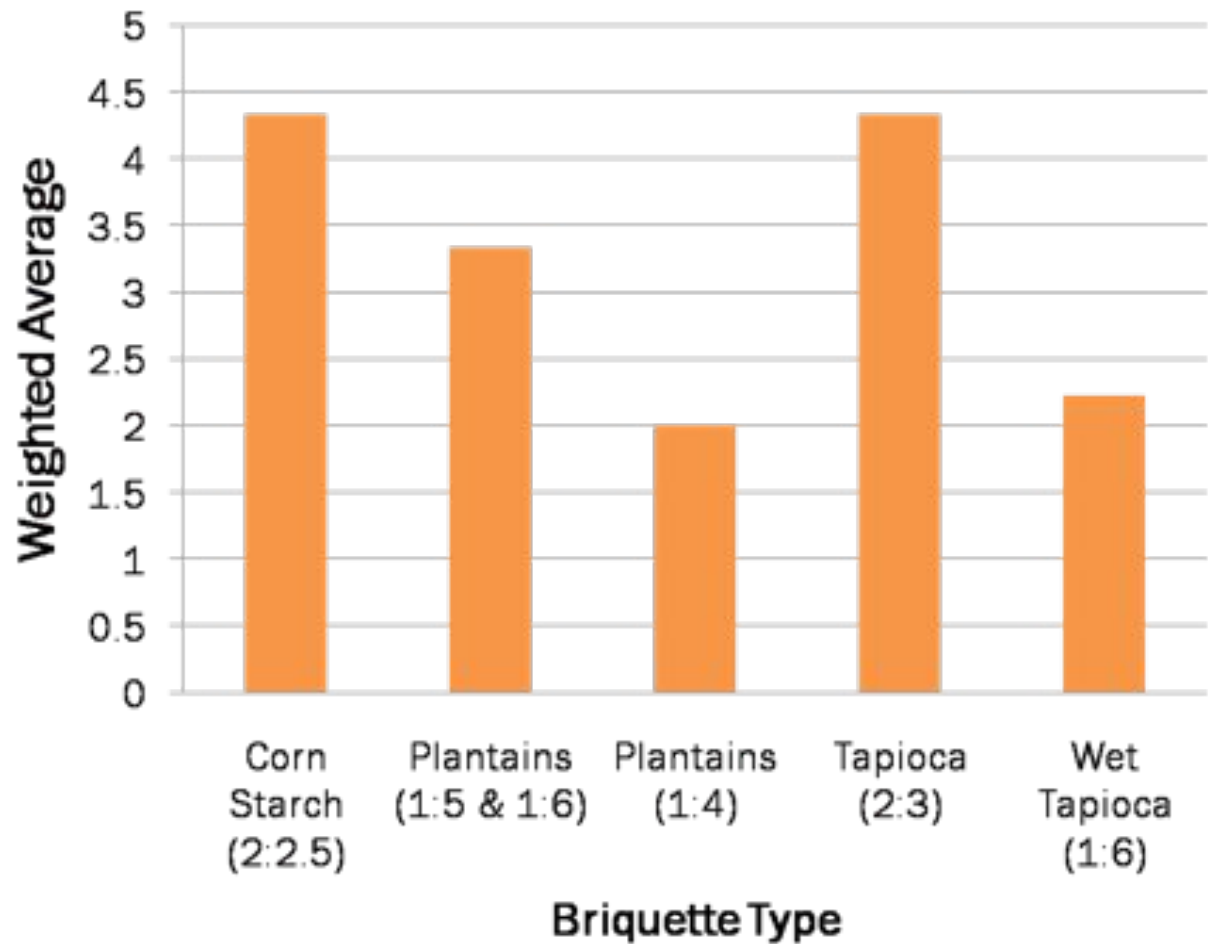
- Corn starch
- Tapioca
 - Flour
 - Pellets
- Plantain
- Yucca



Binder: In-Class Feedback



Binder: In-Class Feedback



Briquette Design: Grain Size Distribution



Small particles...

- reduce amount of binder required
 - increase density
 - increase combustion efficiency
-
- Fine particles may reduce combustion efficiency

Grain size (mm)	Weight %
Larger than 9.51	6.47
4.76 – 9.51	28.6
2.38 – 4.76	32.5
2.00 – 2.38	5.40
1.19 – 2.00	11.2
0.840 – 1.19	4.26
Less than 0.841	11.5

Qualitative Evaluation

Puck

Difficult to start
Smolders



Donut

Easiest to set fire
Positioning is not as critical





Barriers to adoption

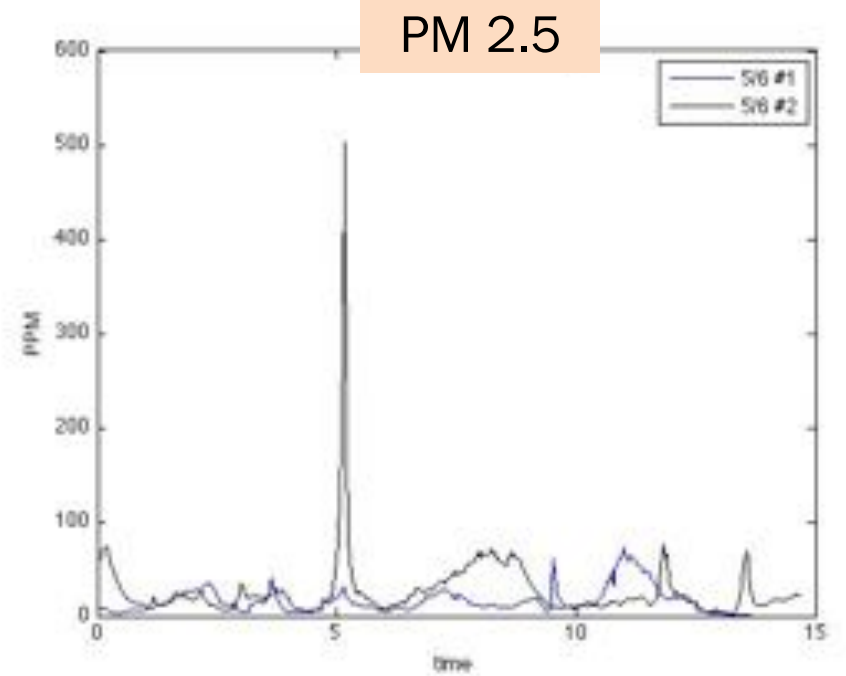
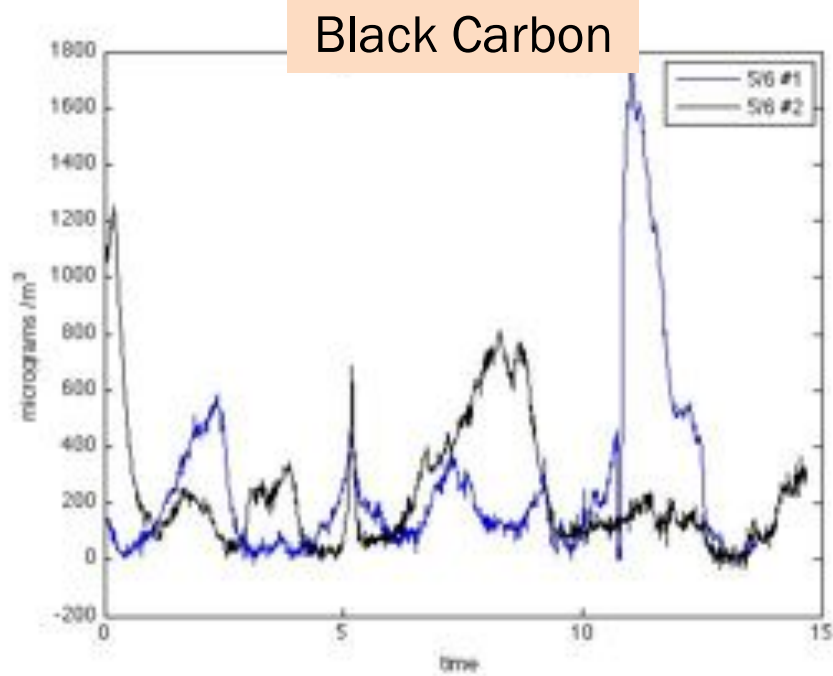
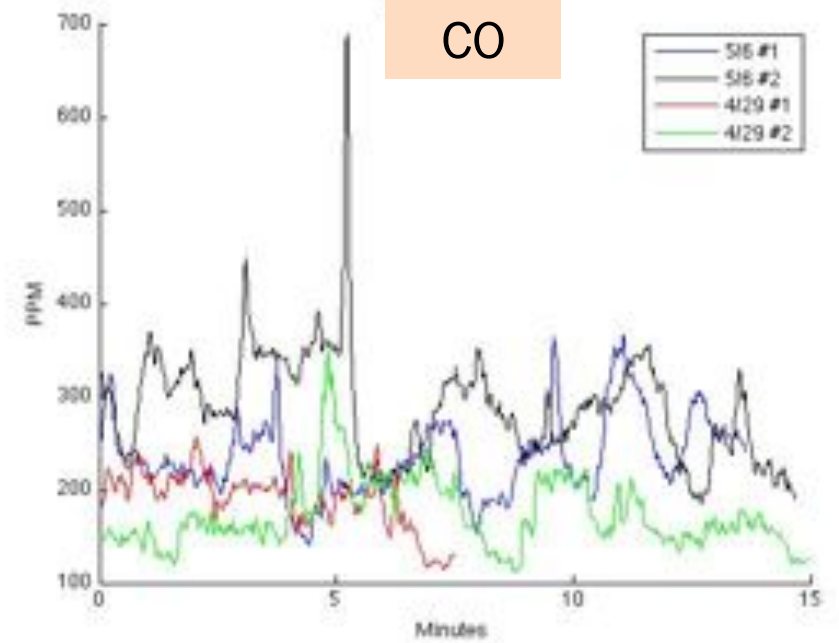
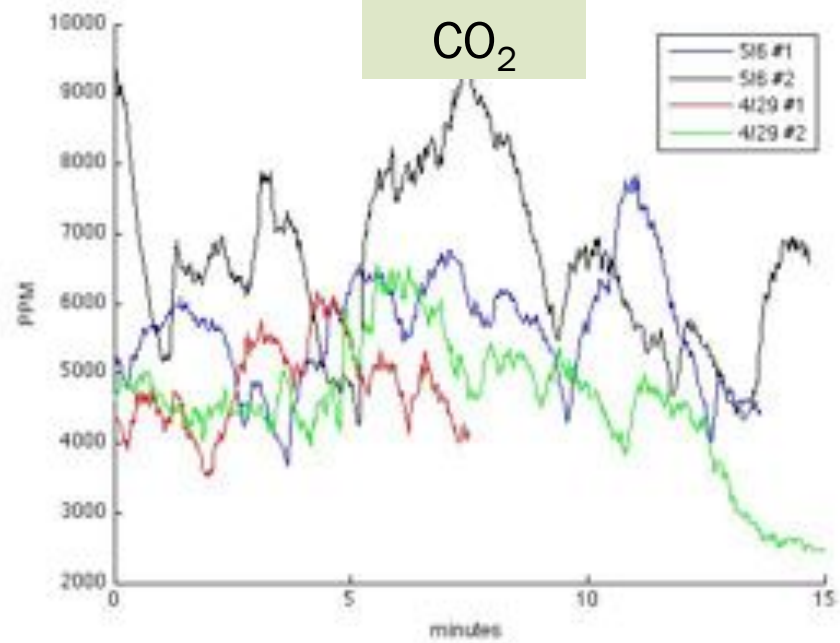
- Binder is a food source
- Time intensive process
- Must be very attentive to stove when using briquettes (rapid feed)
- Drying time

Emissions Test



- Tests Conducted at LBNL Stove Emissions Testing Facility
- Test Procedure
 - Darfur Stove
 - Small Starter Fire
 - Lidded Pot with 2.5 l of H₂O
 - Maintain 15 min Boil







Average emissions to sustain 2.5L H₂O at 100° C for 15 minutes in a Darfur Stove

Emissions Test: Results

	Wood (representative avg)	Peanut Briquettes (n=4)	% Change
CO ₂ (PPM) ¹	3300	5000	50%
CO (PPM)	130	220	69%
PM 2.5 (PPM)	7.9	22	<u>180%</u>
Black Carbon (µg/m ³)	98	260	<u>160%</u>
Burn Rate (g/min)	6.0	8.4	36%

1. Emissions above background



Implementation Dilemma

Theoretical max of ~50 days' worth of fuel for average smallholder

- Need a lot more shells...

“Collectively, if people are willing to share money with each other from other families, then they can join together and make a business, but it is not extremely common. **It's more common that one person/family, who is more well off, will hire piece workers to help.**”

--Amanda Shing, MIT D-Lab (3/22/10)

Approach



- Individual/family able to do large-scale processing
 - Need many hectares' yield of peanut shells
 - Standardized quality improves marketability
 - Avoids uncertainty of community cohesion
- Sell UNS, briquette press, and training all together
 - With marketing techniques!



Marketability

- Market viability questionable
 - Price would be 1.3x equivalent amount of charcoal, using minimum wage labor
 - To achieve competitive price (1/2 charcoal), labor costs as low as 3-4 MK (2¢) per hour
- Margins likely to be quite low
 - Payback not rapid enough?
- Based on crude assumptions
 - And lack of feedback from key stakeholders



In a nutshell...

- Barriers to adoption need to be addressed
- Not better than wood with respect to emissions
 - Potentially worse!
- Not a market-viable project currently
- Must address general challenges of agri-waste fuels
 - Displacing wood and improving health may run contrary



Future Directions

- Calorimetry of peanut shells
 - Are they actually special?
- Improve general agricultural waste processing
 - Optimal recipes
 - Business plan
- Consumer testing of briquettes



Thank you

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- Johanna Mathieu
- Ashok Gadgil



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